Amendments to the Specification:

Please replace paragraph [0005] with the following paragraph:

[0005] A position control system according to the present invention is used for controlling a fluid operated cylinder having at least one fluid chamber defined by a piston located within a housing for movement between first and second end limits of travel. The system includes at least two electrically actuated proportional flow valves connected to each port of the fluid operated cylinder to be controlled for selectively and proportionally controlling fluid flow into and out of the at least one fluid chamber of the fluid operated cylinder to be controlled. At least one pressure sensor is provided for measuring fluid pressure with respect to each chamber of the fluid operated cylinder to be controlled. At least one ~~discreet~~ discrete position sensor is located adjacent a midpoint of the fluid operated cylinder to be controlled for sensing a ~~discreet~~ discrete centered position of the piston within the cylinder. A control program according to the present invention is operably connected to the at least two valves, the at least one pressure sensor, and the at least one position sensor for controlling actuation of the at least two valves in response to pressure measured by the at least one pressure sensor and location measured by the at least one position sensor.

Please replace paragraph [0010] with the following paragraph:

[0010] The present invention implements a pneumatic cylinder control scheme with a cost comparable to a simple system, but with performance approaching that of a complex system. The control scheme according to the present invention is a combination of hardware and software. The hardware is supportive of the required functions. However, actual operation is determined by the software. Further, the software is constructed in such a fashion that variables determine the actual final operation. This approach ~~allows~~ allows, for example, a variety of motion profiles, i.e. control of acceleration/deceleration profiles, velocity, timing, force, repetition, etc. In

addition, this control scheme allows operation of either dual acting cylinders or single acting cylinders. In other words, the present invention can operate cylinders with fluid control on both sides, or cylinders with fluid on one side and a mechanism such as a spring to cause return on the other side. Although the description contained herein is oriented toward pneumatically operated cylinders, the control scheme according to the present ~~invention,~~ invention as described also applies to other fluids such as hydraulics or other liquids. In yet another application of this control scheme, the cylinder can be replaced by a main stage valve. These are typically very large valves. In this case, the control scheme acts as a proportional pilot for the mainstage, allowing proportional positioning of the mainstage valve. Historically, the valve industry has used complex methods such as torque motors or proportional valves with precision ~~fee-back~~ feedback for controlling such mainstage valves. The device used for this application is referred to as a valve positioner control. The control scheme described herein according to the present invention can therefore be used to replace the existing positioner control. As with the cylinder, the mainstage valve can be operated with various fluids and can operate as a dual acting or as a single acting mainstage positioner.

Please replace paragraph [0012] with the following paragraph:

[0012] In order to implement this type of control, three variables are monitored. First, two signals corresponding to the pressure in both chambers of the cylinder are required. This is achieved by pressure transducers on each inlet to the cylinder. Additionally a ~~hall-effect~~ Hall-effect sensor, or other type of ~~discreet~~ discrete position sensor, is used at mid-stroke to re-calibrate the system occasionally, thus maintaining system accuracy.

Please replace paragraphs [0016] – [0021] with the following paragraphs:

[0016] If we assume that the temperatures are equal, the equation is simplified

to:

$$\cancel{P_oV_o=P_1V_1} \quad \underline{P_c \cdot V_c = P_l \cdot V_l.} \tag{3}$$

As already described above:

$$\cancel{F=P{\cdot}A} \quad \underline{F = P \cdot A} \tag{4}$$

Where F, P, and A represent Force, Pressure, and Area, respectively.

[0017] This demonstrates that the force exerted within the cylinder is a function of the pressure on that end of the piston times the effective area. The effective area of the cap end of the piston is simply the internal area of the cylinder, and is represented by:

$$\left[\frac{D_i^2 \cdot \pi}{4} = A_c\right] \underline{\frac{D_i^2 \cdot \pi}{4} = A_c} \tag{5}$$

D_i is the inner diameter of the cylinder and A_c is the area of the cap-end of the cylinder.

[0018] The area for the load end of the piston is simply ~~the~~ equation <u>(5)</u> above minus the area of the rod:

$$\left[\frac{(D_i^2 - D_r^2) \cdot \pi}{4} = A_1\right] \underline{\frac{(D_i^2 - D_r^2) \cdot \pi}{4} = A_l} \tag{6}$$

[0019] Now that the area of the piston is known, it follows that the volume of the chambers can be ~~described as:~~ <u>described.</u>

For the cap end<u>, the volume is</u>:

$$[V_c=A_c{\cdot}L_c] \quad \underline{V_c = A_c \cdot L_c} \tag{7}$$

<u>where</u> L_c is the length from the inside end of the cap end to the surface of the piston.

For the load end<u>, the volume is</u>:

$$[V_l=A_l{\cdot}L_l] \quad \underline{V_l = A_l \cdot L_l} \tag{8}$$

<u>where</u> L_l is the length from the inside end of the cap end to the surface of the piston.

Therefore, the volume of air in the cap end of the cylinder is:

$$\left[\mathbf{V}_c = \frac{D_i^2 \cdot \pi}{4} \cdot \mathbf{L}_c\right] \quad \underline{V_c = \frac{D_i^2 \cdot \pi}{4} \cdot L_c} \qquad (9)$$

~~And~~ and the volume of air in the load end of the cylinder is:

$$\left[\mathrm{V}_1 = \frac{\left(D_i^2 - D_r^2\right) \cdot \pi}{4} \cdot \mathrm{L}_1\right] \quad \underline{V_l = \frac{\left(D_i^2 - D_r^2\right) \cdot \pi}{4} \cdot L_l} \qquad (10)$$

Combining this with equation ~~2~~ (3) yields:

$$\left[\mathrm{P}_c \cdot \frac{D_i^2 \cdot \pi}{4} \cdot \mathrm{L}_c = \mathrm{P}_1 \frac{\left(D_i^2 - D_r^2\right) \cdot \pi}{4} \cdot \mathrm{L}_1\right] \underline{P_c \cdot \frac{D_i^2 \cdot \pi}{4} \cdot L_c = P_l \frac{\left(D_i^2 - D_r^2\right) \cdot \pi}{4} \cdot L_l} \; (11)$$

Finally, the pressures required to move the cylinder a certain distance are:

$$\left[\mathrm{P}_c \mathrm{D}_i^2 \cdot \frac{L_c}{L_l\left(D_i^2 - D_r^2\right)} = \mathrm{P}_l\right] \quad \underline{P_c D_i^2 \cdot \frac{L_c}{L_l\left(D_i^2 - D_r^2\right)} = P_l} \qquad (12)$$

$$\left[P_l \cdot L_l \frac{\left(D_i^2 - D_r^2\right)}{D_i^2 \cdot L_c} = P_c\right] \quad \underline{P_l \cdot L_l \frac{\left(D_i^2 - D_r^2\right)}{D_i^2 \cdot L_c} = P_c} \qquad (13)$$

[0020] Referring now to Figure 1, implementation of the control method according to the present invention can be performed with a multi-valve configuration, such as a four-valve pack, coupled with two pressure transducers; i.e. one transducer for each port of the fluid operated cylinder. The transducers can be off-the-shelf parts, which are commercially available from vendors such as DigiKey. ~~OpAmps~~ Operational amplifiers can be used for signal conditioning in a standard circuit configuration, and ~~feed~~ can be fed into analog inputs of the valve pack. A position control system 10 according to the present invention is illustrated in Figure 1 for controlling a fluid operated cylinder 12 having at least one fluid chamber 14, 16 defined by a piston 18 located within a housing 20 for movement between first and second end limits of travel 22, 24. The system 10 can include at least two electrically actuated proportional flow valves 26, 28, 30, 32 connected to each port 34, 36 of the fluid operated cylinder 12 to be controlled. The valves 26, 28, 30, 32 selectively and proportionally control fluid flow

into and out of the at least one fluid chamber 14, 16 of the fluid operated cylinder 12 to be controlled. At least one pressure sensor 38, 40 is provided for measuring fluid pressure with respect to each chamber 14, 16 of the fluid operated cylinder 12 to be controlled. At least one ~~discreet~~ discrete position sensor 42 is located adjacent a midpoint of the fluid operated cylinder 12 to be controlled for sensing a ~~discreet~~ discrete centered position of the piston 18 within the housing 20. A central processing unit 44 includes a control program and is operably connected to the at least two valves 26, 28, 30, 32, the at least one pressure sensor 38, 40, and the at least one position sensor 42 for controlling actuation of the at least two valves 26, 28, 30, 32 in response to pressure measured by the at least one pressure sensor[,] 38, 40 and location measured by the at least one position sensor 42.

[0021] ~~The at least one discreet position sensor 42 can include a first position sensor 42 located adjacent a midpoint of the fluid operated cylinder, and a second position sensor 46 or 48 located adjacent one end of travel of the piston 18 in the housing 20 for providing soft stop deceleration of the piston 18 prior to contact with an end wall of the housing 20 defining the at least one chamber 14, 16.~~ The at least one chamber 14, 16 can include a first expandable fluid chamber 14 adjacent one end of travel of the piston 18 in the housing 20 and a second expandable fluid chamber 16 adjacent another end of travel of the piston 18 in the housing 20. The at least two electrically actuated proportional flow valves 26, 28, 30, 32 can include a first valve 26 associated with the first expandable fluid chamber 14 for selectively and proportionally controlling fluid flow into the first expandable fluid chamber 14 and a second valve 28 associated with the first expandable fluid chamber 14 for selectively and proportionally controlling fluid flow out of the first expandable fluid chamber 14. The at least two electrically actuated proportional flow valves 26, 28, 30, 32 can also include a third valve 30 associated with the second expandable fluid chamber 16 for selectively and proportionally controlling fluid flow into the second expandable fluid chamber 14 and a

fourth valve 32 associated with the second expandable fluid chamber 16 for selectively and proportionally controlling fluid flow out of the second expandable fluid chamber 16.

Please replace paragraphs [0023] to [0025] with the following paragraphs:

[0023] The control program according to the present invention can initialize a home position corresponding to the centered position of the piston 18 within the housing 20, when the piston 18 is sensed by the at least one ~~discreet~~ discrete position sensor 42 located adjacent the midway position with respect to the housing 20. The control program according to the present invention can also calculate a value corresponding to an amount of pressure required in the at least one expandable fluid chamber 14, 16 for moving the piston 18 a desired distance within in the housing 20 from the ~~discreet~~ discrete centered position located midway with respect to the housing 20. The control program can control the at least two electrically actuated proportional flow control valves 26, 28, and/or 30, 32 to obtain the calculated pressure within the at least one expandable fluid chamber 14, 16 corresponding to the desired distance of movement for the piston 18 within the housing 20. Various means can be provided for biasing the piston 18 toward the ~~discreet~~ discrete centered position with respect to the housing 20. If only a single expandable fluid chamber is provided to be controlled by the present invention, the biasing means can include any suitable mechanical device, by way of example and not limitation, a return spring force. If two expandable fluid chambers 14, 16 are provided to be controlled by the system 10 according to the present invention, the biasing means corresponds to the second expandable fluid chamber. It should be recognized that the pressure calculations described in greater detail above can be modified to correspond to pressure acting against a mechanical spring force when determining the appropriate amount of pressure to provide in a single expandable fluid chamber, and that modifications to the pressure calculations could also be made to

accommodate a dual piston rod configuration rather than the single rod piston configuration described in detail here.

[0024] The cylinder 12 preferably has two active expandable fluid chambers 14, 16 that effect a change in position and force of the piston 18 and connected rod. Two proportional control valves 26, 28 or 30, 32 are connected to each chamber 14, 16. One valve removes fluid, by way of example and not limitation, a fluid such as compressed air or hydraulic fluid, from the connected chamber, while the other valve supplies pressurized fluid to the connected chamber. The system includes control electronics (such as CPU 44), and preferably three pressure transducers[,] 38, 40, ~~42, 48~~ 50. The control electronics 44, along with the onboard software, control the four proportional control valves 26, 28, 30, 32 in response to commands from an external source, by way of example and not limitation, such as commands from a network or computer workstation. The pressure transducers 38, 40, 50 monitor the pressure of the pressurized fluid supply, and both expandable fluid chambers 14, 16 in an effort to control the dispensing of pressurized fluid to and from the expandable chambers 14, 16 to provide accurate positioning control of the piston 18 and connected rod output force. In the preferred configuration, the proportional control valves 26, 28, 30, 32 can be piezo-electric actuated control valves of a type similar to those described in U.S. Pat. No. 6,548,938 issued on April 15, 2003, or a piezo-electric actuator of the type similar to that disclosed in U.S. Design Pat. No. D483,335 issued on December 9, 2003, or PCT Published Application No. WO 04/006,349 published on July 3, 2003, or PCT Published Application No. WO 03/083,957 published on March 25, 2003, or PCT Published Application No. WO 03/067,674 published on January 22, 2003, or PCT Published Application No. WO 01/80,326 published on March 29, 2001, or PCT Published Application No. WO 01/79,731 published on March 29, 2001, all of which are incorporated by reference herein in their entireties. Preferably, by way of example and not limitation, the piezo-electric actuator is controlled for proportional valve operation

by direct control of the voltage applied to the piezo, or by monitoring the amount of energy in the piezo-electric actuator and using a current charge control, which is different than pulse width modulation as used for proportional control of solenoid operated valves.

[0025] ~~Referring now to Figure 2, the~~ The software code controls both pairs of valves on each side of the cylinder simultaneously as described in the control flow chart. The control program according to the present invention can best be understood by reference to Figure 2. The control program can begin by initializing the system in step 100. During the initialization step 100, the control program locates a home or piston-centered position as indicated by a ~~hall-effect~~ Hall-effect sensor, and brings pressure on both sides of the piston 18 to be equal to one another so that there is no movement of the piston 18 within the housing. By way of example and not limitation, the control system can bring the pressure on both sides of the cylinder to 50 psi while at the centered position, which can be verified by the signals received from the at least one position sensor 42 and the at least one pressure sensor 38, 40. Once the system is initialized in step 100, the control program continues to query 102 to determine if a change in position is desired. If a change in position is not desired, the control program returns to the beginning of query 102. If a change in position is desired, the control program continues to step 104 where the necessary pressure is calculated based on the desired movement. The control program then continues to query 106 where it is determined if the desired position is toward the cap end of the cylinder 12. If the desired position is toward the cap end, the program branches to step 108 where pressure is raised in the load end expandable fluid chamber of the cylinder 20. If the desired position is not toward the cap end in response to query 106, the control program branches to step 110 where pressure is raised in the cap end expandable fluid chamber of the cylinder 20.